SCIENCE

MAY 2- 1936

NEW SERIES
VOL. 83, No. 2157

FRIDAY, MAY 1, 1936

SUBSCRIPTION, $6.00
SINGLE COPIES, .15

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

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VOL. 83 FRIDAY, MAY 1, 1936 No. 2157

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

RESUSCITATION WITH CARBON DIOXIDE[1]

By Professor YANDELL HENDERSON

YALE UNIVERSITY

ON the morning of May 9, 1794, in the Place de la Revolution in Paris, Antoine Laurent Lavoisier died under the guillotine.

One hundred and seven years later (1901) Michael Foster in his history of physiology wrote:

> As the sharp stroke of the guillotine severed his neck there passed away from this world, in his fifty-first year, this master mind of science, who had done so much to draw aside from truth the veil of man's ignorance and wrong thought; and there passed away too, the hope of his drawing aside yet other folds of that veil, folds which perhaps wrap us round even to-day.

What I have to say is concerned with one of those "folds of the veil of ignorance and wrong thought" which it has been my good fortune to some extent to draw aside.

A few years before his death Lavoisier had demonstrated the true nature both of combustion and respiration—a fundamental likeness between fire and breathing. It is oxygen, both in combustion and in respiration (in its broadest sense), that unites with carbonaceous matter, liberates heat and produces carbon dioxide.

From this fundamental conception have come far-reaching practical applications and an understanding of the unities of nature that is even more important. We can now measure the energy expenditure of the body by determining the amount of oxygen consumed. We can compare, as Lavoisier suggested, the combustion in the working muscles of a laborer and the reasoning brain of a scientist. We see that respiration

[1] Read before the American Philosophical Society, Philadelphia, April 23, 1936.

is almost life itself; yet not quite, for we find that thought is not merely physical energy.

The lessons of this vast conception are not limited to normal life. They tell us also of the processes involved in dying. As exclusion of oxygen extinguishes a fire, so too in a man or an animal a deficiency of oxygen in the blood and tissues induces death in asphyxia. It is in the tissues and organs that the fundamental process of respiration occurs. Death is the cessation of that process. There are many modes of dying that bring men to their ends; but only one final common cause. Whether the brain is destroyed or the lungs blocked or the heart stopped, death finally occurs but in one way only. When breathing and the heart come to a standstill, the supply of oxygen to the body ceases. Unless a man is burned alive, the tissues of his body always die of asphyxia.

The Problem of Asphyxia

It is only when we ask the question—"What then is asphyxiation?"—that a "fold of the veil of wrong thinking" hides from us the truth and hides even the nature of our ignorance. Asphyxiation is the process that occurs whenever it becomes difficult for the tissues to obtain their normal supply of oxygen. Any absolute deficit kills quickly. Drowning, strangling or suffocation under a pillow, in a grave or in the uterus all stop both the intake of oxygen and the outgo of carbon dioxide. Therefore, it was inferred, an accumulation of carbon dioxide must be as much the cause of death as a deficiency of oxygen. It even came to be assumed that a deficiency of oxygen kills by producing an excess of carbon dioxide. Two facts were overlooked. One is that without oxygen carbon dioxide can not be produced. The other is that in several of the most important forms of asphyxiation (*e.g.*, carbon monoxide asphyxia), while the supply of oxygen is restricted, the elimination of carbon dioxide is still entirely free or is even abnormally augmented. There is thus a deficiency of oxygen and a deficiency of carbon dioxide also.

Nevertheless, almost down to the present time carbon dioxide has been regarded as par excellence the asphyxiant gas. Only a few years ago nothing would have seemed more improbable or more illogical than that inhalation of carbon dioxide, mixed either with oxygen or air, should ever be employed for the resuscitation of the victims of asphyxia. Yet such inhalation has now become the accepted treatment; and in the light of present knowledge it is entirely logical. It is saving many thousands of lives.

The Initial Discoveries

In the autumn of the year 1900 I received my first appointment to teach. Up to that time I had devoted myself chiefly to the chemical side of physiology. Of respiration and the circulation I knew almost nothing. I taught the old doctrine that respiration is regulated reflexly through the vagus nerves from the lungs. I gave little consideration to the chemical control, and that little was concerned chiefly with oxygen, not with carbon dioxide. But in lecturing on the circulation I had the uncomfortable feeling that such a hydraulic apparatus as I described simply would not work.

I read and reread Tigerstedt's "Lehrbuch des Kreislaufs"; and when it failed to clear up the difficulty, I turned to experiments of my own devising. By means of a child's large rubber ball, I constructed a chamber that could be slipped airtight, but without compression, over the ventricles of the heart of a dog. This simple cardiometer was connected by a wide rubber tube to a large tambour made out of the tin top of a tobacco jar. With this extemporized apparatus, writing on one of the only two revolving drums that my ill-equipped laboratory possessed, I recorded for the first time the volume curve of the heart: a curve that, better than any other form of observation, shows the mechanical action of the pump that keeps the blood circulating.

In order to adjust the cardiometer on the heart it was necessary to open the thorax widely. Under these conditions the lungs collapse; and it was necessary to blow air into them, so as to keep them distended, as well as to maintain artificial respiration. For this purpose I had only a leaky hand bellows; and the janitor who worked it for me was compelled to keep up a rapid succession of pulmonary inflations, the lungs undergoing a considerable deflation between strokes. The over-ventilation was therefore tremendous; and the animals quickly went into collapse and died. And the fact that was most striking was that the more energetic the janitor was with the bellows, the more rapidly the animals collapsed.

Acapnia and the Venopressor Mechanism

The collapse consisted in failure of the circulation. Yet the volume curves of the heart showed that it was not the heart itself that failed. Nor was it the vasomotor mechanism on the arterial side of the circulation. It was the venous return to the heart that failed. Thus it appeared, first, that an acute over-ventilation of the lungs may cause failure of the circulation of the blood; and, second, that the failure lay in a hitherto unrecognized third major mechanical factor in the circulation.

Here were two new facts to be explained. First, as to what happens when the lungs are over-ventilated. Mosso, the Italian physiologist, forty years ago had established a hut on Monte Rosa, the second highest peak in the Alps, where he studied the effects of altitude. He found that in mountain sickness the carbon

dioxide of the blood is diminished, and he gave this condition a name. He called it "acapnia," from the Greek word "kapnos," smoke; literally, acapnia means smokelessness—a deficiency of carbon dioxide.

Within a year of my first observations another important piece of collateral evidence came out, this time from England. Haldane and Priestley published their classic demonstration that carbon dioxide, rather than oxygen, is the chief immediate factor in the regulation of respiration. What I had accidentally stumbled upon was the discovery that carbon dioxide is equally potent in the regulation of the circulation.

On the basis of my own observations and those of Haldane and his collaborators, I ventured just thirty years ago to formulate and publish a sweeping hypothesis. It was the so-called acapnia theory of shock: the theory that a deficiency of carbon dioxide is involved in the depression of respiration, circulation and other functions after severe physical injuries and major surgical operations. For fifteen years I campaigned for this theory vigorously, but quite unsuccessfully. It is now, or was until the last few months, generally forgotten, or else referred to only as "one of the disproved and rejected theories."

What I could not achieve by the first fifteen years of direct advocacy has now been won by a maneuver as old as the Trojan horse. This success is the result of another fifteen years in which, avoiding theoretical discussion, I have devoted my efforts mainly along practical lines. I stopped arguing with physiologists and made friends with the anesthetists. We first introduced, as part of the technique of anesthesia, the use of a rebreathing bag to conserve the body's store of carbon dioxide. Then gradually we introduced a mixture of oxygen and carbon dioxide as part of the equipment of the anesthetist. And now cylinders of carbon dioxide, either mixed or pure, are a feature of nearly all operating rooms. And in this way the acapnia theory has captured the citadel of surgery, much as Ulysses and the Greeks captured Troy. They used a wooden horse. The acapnia theory won its entrance in those cylinders of carbon dioxide. And since this almost unnoticed victory, deaths from failure of respiration under anesthesia—once common—have almost ceased to occur.

Muscle Tonus and the Venous Return

Yet I do not blame those who so long rejected the acapnia theory. The only cause of acapnia that I had recognized was excessive elimination of carbon dioxide. I now realize that a deficiency of carbon dioxide may equally well be induced by lowered vitality and decreased production. Furthermore, until quite recently, I could offer no adequate explanation as to how deficiency of carbon dioxide affects the circulation; and failure of the circulation is generally regarded as the most significant feature of surgical shock. Now, however, there is an explanation. It is found in the depression of muscle tonus that is the commonest feature of depression of vitality. When a patient is too weak to stand or to sit up in bed or even to lift his head from the pillow, his condition is one of depressed muscle tonus. We have now demonstrated that tonus, the gentle longitudinal pull of the muscles that normally holds us erect, induces also a transverse pressure between the muscle fibers, in the same way that a pull on a rope causes a pressure between its strands. All the tonic tissues of the body have within them this pressure. Normally it causes the blood to flow from the tissues into the veins and on back to the heart. But when tonus is depressed, this intratissue pressure is also lowered; the blood stagnates in the tissues; and the volume flowing back to the heart is so much diminished that the heart appears to fail. Yet it is not the heart itself that fails. Nor is it the vasomotor mechanism. It is this venopressor mechanism: the third major mechanical factor in the circulation that I sought for so many years and find now in muscle tonus.

The depression of muscle tonus after severe physical injuries and major operations is significant also in another relation. Normally the tonus of the thoracic muscles keeps the chest and lungs expanded. But when vitality is depressed and body tonus is low, the muscles of the thorax, and particularly the diaphragm, relax and the lungs are correspondingly deflated. During this deflation, some of the air passages may be occluded or blocked with mucus; the air back of the block is then quickly absorbed; and areas of atelectasis or even a massive collapse of the whole of one lung may result.

Such conditions favor the development of infection in the lungs; a fact which is important in relation to pneumonia.

The effect of inhalation of carbon dioxide that is generally emphasized is the increased volume of breathing that it induces and the rapid elimination from the blood of any volatile substance such as ether or alcohol or carbon monoxide. But carbon dioxide has another and more fundamental effect. It increases muscle tonus, particularly the tonus of the thoracic muscles and the diaphragm. And thereby it increases the expansion of the chest, dilates the lungs and counteracts their collapse. At the same time it increases the intraabdominal pressure and the intratissue pressure generally throughout the body. It thus increases the venous return of the blood to the heart and supports the circulation.

RESUSCITATION FROM ASPHYXIA

While this use of carbon dioxide was developing in surgery, there has been a parallel development in another field. Carbon monoxide is the chief poisonous constituent of illuminating gas and of automobile exhaust gas. It owes its toxicity to the fact that it combines with the hemoglobin of the blood, displacing oxygen and thus inducing asphyxia, even though the victim is breathing vigorously. Haldane had showed that the combination of carbon monoxide with hemoglobin is reversible. The logical treatment appeared therefore to be inhalation of oxygen. Experience showed, however, that this treatment is not very effective and that it is less and less effective the severer the gassing. This was rather a puzzle, until Dr. H. W. Haggard and I found the reason. It is that, during the development of asphyxia, the victims—our victims were dogs—overbreathe excessively and develop an acapnia that depresses both respiration and circulation profoundly. Oxygen is then ineffective, because an inadequate amount is drawn into the lungs. As soon as we knew this, the solution of the problem became clear. We replaced oxygen with a mixture of carbon dioxide and oxygen: at first, 5 per cent. carbon dioxide, and now 7 or 8 per cent. And we devised and introduced a suitable inhalator. As a result this treatment is now so generally used and is so effective in saving life that the mortality from accidental asphyxiation in all our large cities is greatly diminished, and in many communities suicide by means of carbon monoxide is much less popular than formerly.

From the use of carbon dioxide diluted with oxygen for the treatment of carbon monoxide asphyxia another application has now developed. The same treatment has proved effective in the resuscitation of the newborn. The saving of life that can thus be achieved amounts to at least one baby out of every three or four that now die: one in every hundred births: in other words, a saving of more than one per cent. of all human lives. It was by the use of this inhalational treatment that Dr. Dafoe established the respiration of the Dionne quintuplets.

THE FALLACY OF ACIDOSIS[2]

I have here attempted to sketch in twenty minutes the work of more than thirty years. In the early years my proposals met with vigorous opposition, based on a false conception of the function of carbon dioxide in the body. In recent years the administration of carbon dioxide, particularly to the newborn, has been even more vigorously opposed because it contravenes one of the main doctrines of biochemistry—the dogma of acidosis. According to that dogma, all the conditions now treated with carbon dioxide involve an acute acidosis; and inhalation of carbon dioxide should—theoretically—intensify the acidosis. So vigorously have some biochemists urged this objection that they seem almost to think it sinful to save life, if the method of resuscitation involves a violation of the dogma of acidosis.

In answer, I would point out that what is now commonly called acidosis—in the sense of an intoxication by excess of acid—is more correctly conceived as a form of acapnia; for it is relieved by inhalation of carbon dioxide. In my opinion the present conception of acidosis is one of the "veils of ignorance and wrong thought" that still hides from physiology and biochemistry the true nature of the process through which the vast majority of all lives end: the process of asphyxia in its two phases—deficiency of oxygen and deficiency of carbon dioxide.

MICROPHOTOGRAPHIC DUPLICATION IN THE SERVICE OF SCIENCE

By WATSON DAVIS

DIRECTOR OF SCIENCE SERVICE, WASHINGTON, D. C.

As one of its science research aid activities, Science Service has organized a Documentation Division for the development of microphotographic duplication mechanisms, and the experimental operation of two services in scientific documentation: Bibliofilm Service, in cooperation with the Library of the U. S. Department of Agriculture, and the auxiliary Publication Service, operated in cooperation with scientific journals.

Microphotographic duplication consists of making reduced-size photographs, as when a typewritten or printed page is photographed on a frame of 35 mm motion picture film. In 1925 the late Dr. Edwin E. Slosson, first director of Science Service, and the writer became interested in applying microphotographic duplication to scientific literature and publication, following a suggestion from Dr. F. G. Cottrell. Unsuccessful attempts were made at that time to enlist the cooperation of photographic and optical concerns.

[2] For literature, see Y. Henderson: *Bull. N. Y. Acad. Med.*, 11: 11, 639–656, November, 1935; *The Lancet*, July 27, 1935, p. 178; *Am. Jour. Physiol.*, 114: 2, 261–272, January, 1936; SCIENCE, 79: 2057, 508–510, June 1, 1934; *Journal of A.M.A.*, 101: 261–266, July 22, 1933; *ibid.*, 103: 750–754, September 8, 1934, and 103: 834–837, September 15, 1934.

Microphotographic duplication, both as an idea and practically, is not new. Perhaps the first use was in the early days of photography when Dagron made in 1870 remarkable reductions of printed dispatches upon photographic film so that intelligence could be carried by pigeons out of Paris, then besieged by the Germans.[1]

In recent years, thanks to motion picture apparatus and miniature cameras of the Leica type, a considerable amount of copying of manuscript and book material upon film has been done at the Library of Congress (Rockefeller Project A), Yale University, New York Public Library and elsewhere. There has been some commercial development of copying upon film for record purposes, as for bank checks and legal records.

In 1933 and 1934 discussions were held by circulation of memoranda and conferences looking toward the use of microphotographic duplication in connection with scientific literature. One result was the establishment in November, 1934, of Bibliofilm Service in the Library of the Department of Agriculture through cooperation of Miss Claribel R. Barnett, librarian, Dr. R. H. Draeger, of the U. S. Naval Medical School, who provided mechanisms, and Dr. Atherton Seidell, of the National Institute of Health. Bibliofilm Service copied upon 35 mm film material in the library, substituting microfilm for loan of the books and journals.

In July, 1935, following conferences, the interest of Francis P. Garvan, president of the Chemical Foundation, was obtained and a Chemical Foundation grant of $15,000 was made available, with the result that the Documentation Division of Science Service was formed.

Since cameras, reading devices and other mechanisms for microphotographic duplication were not commercially available, it was necessary to engage in a mechanism development program. In this the primary cooperation of the U. S. Naval Medical School was obtained, with the result that Dr. Draeger, whose camera was being used by Bibliofilm Service, took charge of the mechanisms development. In this work cooperation has also been obtained from the U. S. Bureau of Census, the Works Progress Administration, the Library of Congress, etc. Through cooperation with the U. S. Department of Agriculture, a microphotographic duplication laboratory was installed in the Library of the U. S. Department of Agriculture for the use of Bibliofilm Service, for testing mechanisms and for applying microphotographic duplication to other phases of scientific literature. Science Service assumed operation of Bibliofilm Service on January 1, 1936. Resources are in hand for continuing mechanism development through June 30, 1936, and operation of Bibliofilm Service and the Publication Service through March 31, 1937.

The mechanisms being developed consist of:

(1) Camera for copying typescripts, books, photographs, etc., upon 35 mm film* (in use).

(2) Supplementary apparatus for camera, such as book holder for camera,* film container, etc. (models completed).

(3) Reading machine—about size of typewriter, producing large-sized, easily readable image of 35 mm microfilms (model completed).

(4) Microfilm viewer—a small monocular optical device for reading 35 mm microfilms a line at a time, suitable for inspecting film or for use while traveling. Will sell for about a dollar. (Design completed.)

(5) Projection printer—automatic device for producing photocopies (enlargements upon paper) from 35 mm microfilm negatives* (under design).

(6) Developing and processing apparatus for 35 mm microfilm and paper projection prints* (in use and under design).

* Primarily intended for use in microphotographic laboratories.

Commercial production of these mechanisms is in prospect. One interesting fact is that Bibliofilm Service has operated thus far without adequate reading devices being readily obtainable, several hundred thousand pages of microfilm having been distributed to be read by means of makeshift apparatus, such as dissecting microscopes, movie or slide film projectors or hand lenses.

Microfilm is being produced at a cost to the user of about a cent a page. An enlargement of about 5 to 10 diameters is necessary for easy reading of microfilms, and optical aid is therefore required. For reading without optical aid, photocopies about 6″ × 8″, made by projection from microfilm negatives, are supplied at a cost of about five cents a page.

Bibliofilm Service copies to order material in the Library of the U. S. Department of Agriculture. Order blanks and complete details of Bibliofilm Service are available. Eventually it is hoped to be able to extend Bibliofilm Service to other libraries, thus making more of the literature of science available to scientific research workers.

The Publication Service is intended to break the log jam that now dams scientific publication in many fields, making it possible to put into the realm of accessible scientific literature material of all sorts that can not now be printed because of economic factors. It should also make available valuable research data that now go unrecorded. This service is auxiliary to the present established channels of scientific publication and it is designed to aid and not to hinder scientific journals. Editors of scientific journals would act as

[1] L. Bendikson, *Library Journal*, February 15, 1935.

intermediaries between the authors of papers and the Publication Service.

The procedure for publication of scientific material that does not now have complete or prompt issuance is as follows:

(1) Editors of journals or institutions deposit typescripts of those papers or portions of papers they can not publish promptly or completely. They publish abstract, summary or short paper, including statement that additional text, illustrations, tables, etc., are available upon request from Science Service if document number is stated and price remitted.

(2) Document is assigned a number by Science Service and on receipt it is microphotographed on 35 mm film master negative. Original of document would then be deposited in another location as a safeguard.

(3) Scientists know of availability of document from notice in scientific journal. When and if copy of document is ordered, 35 mm negative is used to make microfilm print or photocopy (projection print) as required.

Microphotographic duplication fills a gap in the present methods of reproduction of scholarly or intellectual material. It is economical for making copies when only one to perhaps 25 copies at a time are needed. One important phase of the method of publication outlined is that a document will be continuously "in print," as the negative can be used to make a copy on demand at any time.

Detailed discussions of various phases of microphotographic duplication are contained in documents issued by Science Service. Literature will be sent on request to Science Service, 2101 Constitution Ave., Washington, D. C.

OBITUARY

ARTHUR J. WEED

ARTHUR J. WEED, of the University of Virginia, Charlottesville, died suddenly on April 15. His interest in seismology was developed at the Weather Bureau, where, as a mechanician, he did the principal work of construction on the Marvin seismograph. Later he built an inverted pendulum seismograph and installed it at the Rouse Physical Laboratory of the University of Virginia where it has continued in operation to the present time and furnished useful data on many earthquakes.

Mr. Weed also designed the Weed strong motion instrument of which eleven have been installed by the Coast and Geodetic Survey in various places in California.

Mr. Weed had the remarkable record of having attended every one of the widely scattered meetings of the Eastern Section of the Seismological Society of America, which have ranged from Ottawa, Canada, to Columbia, South Carolina. He also attended the last meeting of the Seismological Society of America at St. Louis, Mo. At the time of his death he was treasurer of the Eastern Section of the Seismological Society of America.

In the passing of Mr. Weed, the science of seismology has lost one who has given much thought to instrumental problems, an active worker and a true friend.

N. H. HECK

AGNES POCKELS

AGNES POCKELS died on November 21, 1935, at the age of seventy-three years.

Born in Venice in 1862, of German parents, in a period when the ordinary avenues of higher education were hardly accessible to a woman, the lively interest in science which she early developed was forced to seek its outlet in self-education mainly by the aid of books. At the age of nineteen she made her first important experiment in the observation of surface phenomena and in the following year devised the simple means of measuring the relation between surface tension and surface area which has become a most important scientific tool in the hands of such investigators as Lord Rayleigh, I. Langmuir, R. Marcelin and N. K. Adam. She published fourteen papers, the first in 1891, the last in 1926, dealing with surface tension, the spreading of liquid films and the angle of contact. In 1931 the Kolloid Gesellschaft awarded her the "Leonard Prize" and the Technische Hochschule of Braunschweig awarded her the degree of "Dr. Ing. E. h." Her life work has been described by Professor Wo. Ostwald in the *Zeitschrift,* vol. 58, page 1 (1931). Her achievements have earned the admiration of all those who have had occasion to learn of them.

HARRY EAST MILLER

RECENT DEATHS

ALBIN HERMANN BEYER, since 1920 professor of civil engineering at Columbia University, died on April 19. He was fifty-five years old.

DR. ALBERT MOORE BARRETT, professor of psychiatry at the University of Michigan and director of the Michigan State Psychopathic Hospital, died on April 2 at the age of sixty-four years.

DR. THEODORE CLINTON TAYLOR, associate professor of organic chemistry at Columbia University, died on April 20 at the age of forty-four years.

SCIENTIFIC EVENTS

THE BANTING RESEARCH FOUNDATION

DURING the year 1934–35 the board of trustees of the Banting Research Foundation was reconstituted and now consists of the following members: *Chairman,* C. S. Macdonald, president of the Confederation Life Association; *Vice-chairman,* the Hon. Dr. H. J. Cody, president of the University of Toronto; *Honorary Secretary-Treasurers,* Professors V. E. Henderson and D. T. Fraser; *Members,* Sir William Mulock, chancellor of the University of Toronto; Dr. H. B. Anderson, Dr. J. G. FitzGerald, Dr. W. E. Gallie and J. W. Rogers.

Grants which were operative during the year were received by Dr. A. C. Abbott, University of Manitoba, for the study of the thyroid gland; Dr. H. H. Burnham, University of Toronto, for the study of the anatomy and physiology of the nasal mucosa; A. Cipriani, McGill University, methods for the continuous recording of heart rate and respiration; B. K. Coady, Dalhousie University, a study of the lymphocytes; Dr. A. M. Davidson, University of Manitoba, the so-called mosaic fungus; K. A. Evelyn, McGill University, the photoelectric colorimeter and its clinical applications; Dr. R. D. Heard, University of Toronto, adrenalin; Miss C. O. Hebb, McGill University, the relationship between blood sugar concentration and the external secretion of the pancreas; Dr. W. B. Hendry, University of Toronto, the changes in the ureters during pregnancy; Dr. L. Irving, University of Toronto, carbon dioxide anhydrase; Dr. M. J. Lawson, University of Toronto, the carbohydrate metabolism of the kidney; Dr. T. S. Perrett and Dr. D. G. Murray, University of Toronto, on the prevention of thrombosis by heparin; Dr. J. Prendergast, University of Manitoba, thyroid studies; Dr. F. Smith, McGill University, on the culture and growth of the streptococcus; Dr. W. H. M. Thompson, University of Western Ontario, the replacement of retinal detachments; Dr. B. M. UnKauf, University of Manitoba, the innervation of the human stomach; Dr. M. C. Watson, University of Toronto, a clinical study of female sex hormones; Dr. S. Weinstein, University of Toronto, the assay of the oestrus-inducing hormone.

Some fifteen papers appeared during the year, of which the most important were: H. H. Burnham, Toronto, "An Anatomical Investigation of the Blood Vessels of the Lateral Nasal Wall"; P. H. Gregory (with Dr. A. M. Davidson), "The Dermatophytes" and R. D. Heard, "The Mechanism of Adrenaline Stabilization." Further, as a result of the grant made to the department of medical research of the University of Toronto, under Sir Frederick Banting, eight papers were published, dealing with the enzyme phosphatase, silicosis, blood iodine in health and disease and the phosphoric esters of malignant tissues.

The trustees acknowledge the cooperation of the heads of the various departments in the universities. The present financial depression, however, has greatly increased the difficulties of many departments in extending the sphere and scope of the investigations they can afford and the foundation has been able to aid in advancing the solution of many problems.

GRANTS IN AID OF RESEARCH OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES

AT its April meeting the American Academy of Arts and Sciences announced grants from its Permanent Science Fund as follows:

To Professor Arthur A. Blanchard, of the Massachusetts Institute of Technology, $200 for technical assistance in an investigation of the composition and properties of the compound formed by the action of phosphorus trichloride on nickel carbonyl.

To Professor Charles T. Brues, Harvard University, $1,300 to provide the expenses of a field trip to secure Cretaceous amber containing inclusions of insects.

To Dr. Joseph Copeland, College of the City of New York, $500 to aid in the publication of a monograph entitled "Ecological and Taxonomic Studies of the Thermal Blue-green Algae (Myxophyaceae) of the Yellowstone Hot Springs."

To Professor Robley D. Evans, Massachusetts Institute of Technology, $300 for constructing an electric furnace to be used in a series of studies of the age of various minerals.

To Dr. and Mrs. Carroll L. Fenton, West Liberty, Iowa, $350 to aid them in a critical study of certain corals.

To Professor Louis F. Fieser, Harvard University, $1,000 for aid in the study of the composition of various natural compounds by a new method of precision analysis.

To Professor Harry R. Mimno, Harvard University, $500 for expenses in connection with making certain ionosphere observations in Russia and Turkestan during the total eclipse of the sun which will occur on June 19.

To Dr. Wilson M. Powell, Connecticut College for Women, $220 for certain apparatus to be used in studying light intensities.

To Professor Paul Weiss, University of Chicago, $300 for providing moving picture equipment to be used in studying movements of supernumerary (grafted) muscles and limbs in the Amphibia.

Applications for grants-in-aid will be received by the committee until September 15 for action at the October meeting of the academy. Applications should be addressed to Professor E. M. East, chairman of the Permanent Science Fund Committee, Bussey Institution, Forest Hills, Boston, Mass.

MEDAL DAY AT THE FRANKLIN INSTITUTE

AWARDS of the Franklin Institute, Philadelphia, will be formally presented at its Medal Day exercises on Wednesday afternoon, May 20. In addition to the award of Franklin medals to Dr. Frank Baldwin Jewett, vice-president of the American Telephone and Telegraph Company and president and director of the Bell Telephone Laboratories, and to Dr. Charles Franklin Kettering, vice-president and director of the General Motors Corporation, announced in the issue of SCIENCE for April 3, the following medals will be awarded:

The Elliott Cresson Medal

Founded in 1848 by Mr. Cresson, of Philadelphia, to Dr. George O. Curme, Jr., Carbide and Carbon Chemicals Corporation, New York City, "In consideration of his foundation of a new technology which has resulted in the development of a rapidly expanding industry, namely, that of synthetic aliphatic compounds based upon the olefines as starting material; and his development of profitable uses for these compounds in industry"; and to Dr. Robert J. Van de Graaff, of the Massachusets Institute of Technology, "In consideration of his development of an electrostatic generator for the production of high voltage direct currents, through which he has made possible the extension of nuclear investigation."

The Edward Longstreth Medal

Founded in 1890 by the late Edward Longstreth, Baldwin Locomotive Works, Philadelphia, to Dr. Alfred V. de Forest, president of the Magnaflux Corporation, New York City, associate professor at the Massachusetts Institute of Technology, and to Major William E. Hoke, consulting engineer, Baltimore, "In consideration of the new application of certain long-known principles to fill the need for a ready means of detection of hidden defects, primarily at or near the surface of magnetic materials, and of the development of means for the commercial application of this method to present-day engineering problems"; to Peter P-G. Hall, president, Hall Planetary Company, Philadelphia, "In consideration of his invention and development of machine and cutters for planetary milling and threading"; to Elmer A. Sperry, Jr., vice-president, Sperry Products, Inc., Brooklyn, N. Y., "In consideration of his initiative and for his work in the development of blind flying instruments employing gyroscopic principles, which development includes the gyroscopic horizon, directional gyro and automatic airplane pilot."

The John Price Wetherill Medal

Founded in 1925 by the family of the late John Price Wetherill, to Albert L. Marsh, president, Hoskins Manufacturing Company, Detroit, Michigan, makers of electric furnaces, pyrometers and resistance wire. Mr. Marsh is to receive the award, "In consideration of the contribution of a material which has proved of extreme importance to the electrical industries."

The Walton Clark Medal

Founded in 1926 by the United Gas Improvement Company in honor of their chief engineer, who has been, for seventeen years, president of the Franklin Institute, to Dr. Joseph Becker, The Koppers Construction Company, Pittsburgh, Pa., "In consideration of his improvements in the art of carbonization of coal and manufacture of gas in coke ovens, and particularly for his work in the development of the oven known as the 'Becker Oven.'"

The Louis Edward Levy Medal

Founded in 1923 by the family of the late Louis Edward Levy, Philadelphia, to Mayo Dyer Hersey, Brown University, in consideration of his papers on the theory of lubrication, published in the June, July, August and September issues of the *Journal* of the institute for 1935.

The Howard N. Potts Medal

Founded by Mr. Potts, to Dr. Felix A. Vening Meinesz, Amersfoort, Holland, professor of geodesy and geophysics at the University of Utrecht, "In consideration of the outstanding value of his work in geodesy; and the energy, originality and skill he has shown in the development and use of apparatus for determining gravity at sea." Dr. Vening Meinesz will be unable to come to America to receive the award. It will therefore be presented in absentia.

THE AMERICAN PHILOSOPHICAL SOCIETY

AT the annual meeting of the American Philosophical Society held in Philadelphia on April 23, 24 and 25, the following members were elected:

Newton Diehl Baker, Cleveland, Ohio.

Dr. Charles A. Beard, New Milford, Conn.

Carl Becker, professor of history, Cornell University.

Dr. John Rogers Commons, professor of economics, University of Wisconsin, director, American Bureau of Industrial Research.

Dr. Edward Samuel Corwin, McCormick professor of jurisprudence, Princeton University.

Dr. Karl K. Darrow, physicist, Bell Telephone Laboratories, New York.

Dr. Charles Derleth, dean of the College of Engineering of the University of California.

Dr. William E. Dodd, United States Ambassador Extraordinary and Minister Plenipotentiary to the German Reich, formerly professor of history at Randolph-Macon College and at the University of Chicago.

Merritt Lyndon Fernald, Fisher professor of natural history at Harvard University.

Cecelia Payne Gaposchkin, astrophysicist, assistant at the Harvard College Observatory.

John Story Jenks, president of the University of Pennsylvania Museum.

Dr. Arthur Becket Lamb, professor of chemistry at Harvard University and director of the Harvard Laboratories.

Lawrence J. Morris, director of the National Bank, West Chester, Pa.

Dr. M. H. Morse, professor of mathematics at the Institute for Advanced Study, Princeton.

Dr. William A. Nitze, professor of Romance languages and literature at the University of Chicago.

Dr. Linus Carl Pauling, professor of chemistry, California Institute of Technology.

Dr. David Moore Robinson, Collins Vickers professor of archeology and epigraphy, the Johns Hopkins University.

Adolph H. Schultz, physical anthropologist, Baltimore.

Dr. James T. Shotwell, professor of history at Columbia University, director of the Division of Economics and History, Carnegie Endowment for International Peace.

Dr. George Gaylord Simpson, associate curator of vertebrate paleontology, American Museum of Natural History, New York.

Dr. Alfred Henry Sturtevant, professor of genetics, the California Institute of Technology.

Dr. John Henry Wigmore, professor of law, Northwestern University, and dean emeritus of the Faculty of Law.

Dr. George Grafton Wilson, professor of international law, Harvard University.

Dr. Robert Sessions Woodworth, professor of psychology, Columbia University.

Dr. Robert M. Yerkes, professor of psychobiology, Yale University, director of the Yale Laboratories of Primate Biology.

Foreign Residents

Dr. Peter Debye, director of the Physical Institute of the University of Leipzig, recently appointed professor of physics at the University of Berlin.

Dr. Hu Shih, dean of the College of Liberal Arts, the Peiping National University.

Thomas Garrigue Masaryk, first president of the Czechoslovak Republic, formerly professor of philosophy in the University of Prague.

Officers reelected were: *President,* Roland S. Morris; *Vice-presidents,* Edwin G. Conklin, Robert A. Millikan and Henry H. Donaldson; *Secretaries,* John A. Miller and William E. Lingelbach; *Curator,* Albert P. Brubaker. Four *councillors* were elected as follows: Max Farrand, Joseph Erlanger, George H. Parker and Marshall S. Morgan.

SCIENTIFIC NOTES AND NEWS

DR. REID HUNT, who retires from the professorship of pharmacology at the Harvard Medical School this year, celebrated his sixty-sixth birthday on April 20. On this occasion about fifty of his colleagues, former students and friends gathered at the Harvard Club of Boston to do him honor. Dean C. Sidney Burwell was toastmaster. Short speeches were made by Dr. A. Lawrence Lowell, Professor James F. Norris, Professor Ross G. Harrison, Dr. K. K. Chen, Dr. Worth Hale and Dr. G. Philip Grabfield. Presentation was made of an etched portrait of Dr. Hunt, which will hang in the medical school.

THE doctorate of laws of the University of California was conferred on the occasion of the Charter Day exercises on Dr. T. Wayland Vaughan, director of the Scripps Institution of Oceanography. At the Charter Day exercises of the university at Los Angeles the degree was conferred on Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research.

DACCA UNIVERSITY, India, recently conferred the honorary degree of doctor of science on Sir Jagadis Chandra Bose, professor emeritus of physiology at the Presidency College, Calcutta.

THE gold medal of the Royal Society of Canada has been presented to Dr. James B. Collip, professor of biological chemistry in the Faculty of Medicine of McGill University.

THE Board of Directors of the American Foundrymen's Association has awarded to Dr. Heinrich Ries, head of the department of geology of Cornell University, the Joseph S. Seaman gold medal "in recognition of his outstanding services to the foundry industry and to the association in the field of foundry sand research and control."

THE David Livingstone Centenary Medal was presented to Lincoln Ellsworth in recognition of his polar explorations at a meeting of the American Geographical Society on April 21. Presentation of the medal was made by Roland L. Redmond, president of the society. Mr. Ellsworth's attempt to reach the North Pole with Raoul Amundsen by airplane in 1925 and their flight the following year from Spitzbergen to Alaska in the Italian airship *Norge* were described by Mr. Redmond. After the presentation, Mr. Ellsworth delivered an address dealing with his flight, illustrated by still and motion pictures. Dr. John

H. Finley, honorary president of the society, spoke briefly at the close of the address.

THE Messel Medal of the British Society of Chemical Industry, awarded every two years "for eminence in applied chemistry," has been conferred on Sir Robert Mond in recognition of his services to the chemical industry in Great Britain. He has also received the ribbon of the French Legion of Honor in recognition of his researches in applied chemistry and for the support he has extended to archeological researches in Palestine and Egypt.

THE Paul Ehrlich medal has been awarded to Professor Enrique Paschen, of Hamburg, for his researches on smallpox and vaccinia.

DR. DUNCAN A. MACINNES, of the Rockefeller Institute for Medical Research, New York City, was elected president of the Electrochemical Society at the recent meeting held in Cincinnati. Dr. L. H. Baekeland, of the Bakelite Company, past president of the society and a member for over thirty years, was presented with an illuminated certificate of honorary membership.

DR. RAY LYMAN WILBUR, president of Stanford University, has been elected president of the American Social Hygiene Association. He succeeds Dr. Edward L. Keyes, of New York, who resigned recently after serving for twelve years.

THE following officers of the American Society for Pharmacology and Experimental Therapeutics were elected at the recent annual meeting held at Washington: *President,* V. E. Henderson; *Vice-president,* O. H. Plant; *Secretary,* E. M. K. Geiling; *Treasurer,* C. M. Gruber; *Councilors,* Professor C. W. Edmunds and G. Wallace; *Representative on the National Research Council,* W. deB. MacNider.

PROFESSOR HERMAN DIEDERICHS, John Edson Sweet professor of engineering and director of the Sibley School of Mechanical Engineering of Cornell University, has been appointed dean of the College of Engineering to succeed Dean Dexter S. Kimball, who will retire on July 1. The election of Professor S. C. Hollister as associate dean of the College of Engineering, in addition to his regular position as director of the College of Civil Engineering, was also announced.

SAMUEL W. DUDLEY, Strathcona professor of mechanical engineering at Yale University, has been appointed dean of the School of Engineering. He succeeds Dean Robert E. Doherty, who was recently elected president of the Carnegie Institute of Technology.

PROFESSOR THORNDIKE SAVILLE, associate dean of the College of Engineering at New York University, has been appointed dean to take the place of Professor Collins Pechin Bliss, a member of the faculty for forty years and since 1930 dean of the college, who will retire at the end of the year with the title of dean emeritus.

DR. JAMES C. GREENWAY, who has been director of the department of university health at Yale University since it was established under his leadership in 1916, will retire in June. He will be succeeded by Dr. Orville F. Rogers, who also has been associated with the department from the time of its organization, since 1921 as assistant director.

DR. KENNETH F. MAXCY, professor of preventive medicine and bacteriology in the University of Virginia, has been appointed to the professorship of preventive medicine and public health and head of the department at the University of Minnesota. He succeeds Dr. Harold S. Diehl, who last spring was appointed dean of the medical sciences.

AT Princeton University, Dr. Samuel S. Wilks, associate professor of mathematics, has been promoted to a professorship, and Dr. Hadley Cantril, instructor at Harvard University, has been appointed assistant professor of psychology.

DR. CHARLES B. WELD, of the department of physiology of the faculty of medicine at the University of Toronto, has been appointed professor of physiology at Dalhousie University. He succeeds Dr. Ernest W. H. Cruickshank, who resigned in December, 1935.

THE governors of the Rowett Research Institute have appointed Dr. J. T. Irving, lecturer in physiology at the University of Leeds, to be head of the department of physiology of the institute in succession to Dr. R. C. Garry, who recently became professor of physiology at St. Andrews University.

DR. W. E. HARPER, of the Dominion Astrophysical Observatory, Victoria, B. C., who has been assistant director since 1923, is now made director to succeed Dr. J. S. Plaskett, who retired last year. Dr. J. A. Pearce, astronomer since 1924, becomes assistant director.

DR. DAVID SEEGAL, professor of medicine at Columbia University and a member of the staff of Columbia-Presbyterian Medical Center, has been placed at the head of the recently created Research Division of Chronic Diseases in the New York City Department of Hospitals. The committee appointed to make the nomination included: Dr. E. L. Opie, of the Cornell University Medical College; Dr. Alfred E. Cohn, of the Rockefeller Institute for Medical Research, and Dr. M. H. Dawson, of the College of Physicians and Surgeons, Columbia University.

JOHN F. PRESTON, forester for the Hammermill Paper Company, Erie, Pa., has been named head of the woodland management section of the Soil Conservation Service. Mr. Preston will supervise the forestry and woodland phases of the soil erosion control program now being carried on in 141 demonstration areas and more than 450 CCC camps throughout the country. He also will maintain cooperation with the Forest Service and other agencies interested in woodland work.

PROFESSOR DANTE DE BLASI of the Italian Academy has been appointed director of the Health Institute at Rome.

DR. E. WESTON HURST, who is a member of the Lister Institute and reader in pathology at the University of London, has been appointed by the Australian government director of the Institute of Medical Science with a salary of £1,500 a year. This will be the only such institute in Australia, and the government and the University of Adelaide are collaborating in its establishment. The government is contributing £15,000 and a similar amount has been privately subscribed.

DR. JOHN R. MURLIN, of the University of Rochester, has returned after four months leave of absence which he spent in California. On February 26, he gave a lecture before the Society of Sigma Xi at the University of California at Los Angeles, on "New Methods in Human Calorimetry."

DR. LAURENCE H. SNYDER, of the Ohio State University, addressed the Western Reserve Chapter of the Society of Sigma Xi on April 9. His subject was "Heredity and Modern Life."

DR. HARRY C. OBERHOLSER, of the U. S. Biological Survey, delivered an illustrated lecture entitled "A Bird Lover about Baltimore" on April 21 at the Enoch Pratt Free Library. This was one of the series of lectures given each year at the library under the auspices of the Natural History Society of Maryland.

DR. A. B. STOUT, of the New York Botanical Garden, gave an address on "The Origin and Improvement of Cultivated Plants" during the recent annual meeting of the Technical Association of the Pulp and Paper Industry. Special mention was made of the project in breeding hybrid poplars, in which work The New York Botanical Garden has cooperated with the Oxford Paper Company, and of the relation of such breeding to reforestation.

THE American Association of Museums will hold its annual meeting in New York City on May 11, 12 and 13. There will be a general session each morning, and the fourteen sections will meet in the afternoons and on one evening. Monday night will be free and a banquet is planned for Wednesday night.

THE twelfth annual meeting of the Rocky Mountain Section of the Mathematical Association of America was held on April 17 and 18 at the University of Denver. Albert W. Recht, assistant professor of mathematics at the University of Denver, acted as chairman, and A. E. Mallory, Colorado State College of Education, as vice-chairman.

THE Symposium in Theoretical Physics at the University of Michigan will be held between June 29 and August 21. Professor Bethe, of Cornell University, will lecture during the first four weeks on the physics of high speed particles. Beginning with the second week in July, Professor Lawrence, of the University of California, will lecture for four weeks on the design and technique of the cyclotron, artificial radioactivity and the biological action of neutrons. Professor W. Heisenberg, of Leipzig, will discuss various problems of nuclear physics. It is expected that these latter lectures will continue throughout the session. Opportunity for experimental research in nuclear physics with radio-active sources, with the cyclotron and with high potential equipment, will be offered. Those interested in this work should write first for particulars. In addition the department offers numerous graduate courses, and also facilities for research in many lines of theoretical and experimental physics. A special announcement will be sent upon request. Holders of doctor's degrees may attend all sessions as guests of the university.

THE Smithsonian Institution is named in the will of Dr. William Louis Abbott, explorer and naturalist, as beneficiary of one fifth of his residuary estate, and the State of Maryland will receive his 350-acre farm in Cecil County to be maintained as a park or forest reserve. The estate was valued for probate purposes at $535,000, of which $525,000 was the estimate on personalty and $10,000 on realty. Dr. Abbott provided that the Smithsonian Institution, to which he was a large contributor during his lifetime, should have its choice of his papers and books, in addition to its share of the residuary estate.

THIS summer, the University of Denver will establish a high-altitude laboratory on the summit of Mt. Evans, one of the highest peaks in Colorado. The laboratory will consist of two permanent buildings, one, the laboratory proper, and one, the living quarters. Dr. Joyce Stearns and his associates, who have been studying the cosmic ray in cooperation with Dr. Arthur H. Compton, of the University of Chicago, will be in charge.

Industrial and Engineering Chemistry reports that work on the additions to be made to the plant of the Institute of Paper Chemistry at Lawrence College, Appleton, Wis., will probably be ready by commence-

ment. The new quarters will house additional storerooms, offices, laboratories and a large machine room, and will almost double available floor space. They will be informally dedicated and opened to public inspection on June 8, when the institute and the college hold joint commencement exercises.

DISCUSSION

DISTRIBUTION OF TERMITES

IN a recent issue of SCIENCE,[1] A. E. Alexander records *Reticulitermes flavipes* (Kollar) from Ithaca, New York, with the implication that termites are scarce north of the Mason and Dixon line. Such remarks may give an erroneous impression of termite distribution. Termites were recorded from Ithaca in M. D. Leonard's "List of the Insects of New York."[2] Maps in books by C. A. Kofoid and others,[3] and by T. E. Snyder,[4] include Ithaca within the range. As a student at Cornell in 1914–18, I frequently found these insects and can personally state that they are not scarce in central New York. Dr. L. O. Howard states in a letter to Dr. T. E. Snyder that he found termites in 1872 or 1873 in the exact locality mentioned by A. E. Alexander.

There are numerous localities along the northern border of the United States from which termites have been reported. They are now known from every state in the Union and from Vancouver Island, British Columbia. They have not been recorded previously from the Dakotas, but Miss Olive Falls has collected *Reticulitermes tibialis* Banks from Englewood, Centerville, Freeman, Canton and Alcester, South Dakota; the writer has collected the same species at Devil's Tower, Wyoming, not far from the South Dakota border; and Dr. G. C. Wheeler collected this species from a log near Amidon, North Dakota, thus adding the latter state to the records. Miss Olive Falls also collected *R. flavipes* at New Castle, Lincoln County, Maine. Other new northern records furnished by Dr. T. E. Snyder, of the U. S. Bureau of Entomology and Plant Quarantine, are Bellows Falls, Vermont, for *Reticulitermes flavipes;* Gillette, Wyoming, Glendive and Newlon Junction, Montana, for *R. tibialis*. The writer has collected *R. tibialis* near Shoshone Dam, Wyoming, between Cody and Yellowstone Park. E. Goellner has taken *R. flavipes* at Grand Haven, Michigan. Dr. Snyder also has record of damage by an undetermined species of termite at Duluth, Minnesota. Collections along the Canadian border or further north are worthy of record as well as locality records in the northern parts of all the border states.

One commonly finds press reports stating that these destructive insects are spreading, and the above records should not be interpreted as indicating a northward migration. The genus *Reticulitermes* is a distinctly temperate genus and has not been able to invade the tropics. It has been reported from Baltic amber and from the Florissant beds (also Creede) of Colorado—a strong indication that these termites have been in temperate regions for many millions of years. Since there is no valid evidence as yet that would indicate that termites are spreading northward within historical times or are increasing markedly in numbers in any locality, the writer is inclined to discount statements of such increase or extension unless accompanied by critical evidence. Often these statements are part of the propaganda of fear which is spread by persons or firms interested in commercial eradication of termites, either through their own ignorance or through the desire to exploit the ignorance of the lay public. Reputable firms engaged in termite eradication, however, often find a strong tendency for householders to exaggerate the damage caused by termites and, unquestionably, many magnified accounts are merely examples of the human tendency to "improve the truth." Likewise it is also possible to give examples of human apathy when faced with a real termite menace.

There is need for critical data upon the abundance of termites in various localities. Specialists are aware of differences in relative abundance, but exact population studies have not been made and the causative factors governing distribution can only be surmised. The northern and southern extreme limits of distribution throughout the world seem to be correlated fairly well with the 50° F. annual isothermal line. In the United States, the northern limit of distribution is between the 40° F. and the 45° F. annual isothermal lines. Relative humidity and soil moisture seem to be correlated strikingly with the distribution of certain species. Toleration experiments by Dr. O. L. Williams[5] indicate that humidity has a direct effect upon distribution, at least in the case of certain species.

The environmental requirements of the various species seem so rigid that it is very unlikely that species can gain a foothold in environments very different from their native conditions. *Reticulitermes flavipes*, native to the United States east of the Mississippi

[1] Vol. 83, No. 2141, p. 34.
[2] Mem. 101, Cornell Univ. Agr. Exp. Sta., 1926.
[3] "Termites and Termite Control," Univ. Calif. Press, 1934.
[4] "Our Enemy the Termite," Comstock Publishing Company, 1935.
[5] "Termites and Termite Control," Univ. Calif. Press, 1934, 2d edition.

River, was originally described in 1837 from specimens introduced into greenhouses near Vienna, Austria. Even though the climate is not unlike the native habitat, this species did not spread into the surrounding country. Sometime before 1890, *Kalotermes* (*Cryptotermes*) *dudleyi* Banks was introduced into Panama, probably from the Orient. Although now a well-known termite in houses in the Canal Zone, this species has not been able to establish itself in wild situations in the region. *Kalotermes* (*Cryptotermes*) *brevis* (Walker) was introduced into buildings in Durban, Natal, some time before 1921. The native region for this species is the West Indies and Caribbean shores. So far, the records from South Africa are all from a small area in Durban and the species has not been found in wild situations. The same species was found in buildings in Georgetown, British Guiana, in 1920 but does not seem to be established in the wild areas in Guiana. Records of this species in Louisiana and Florida are also all from buildings. Recently the writer has identified a termite as *Heterotermes philippinensis* Light, a native of the Philippines, which was collected by L. P. Regnard on October 13, 1933, in Mauritius. Dr. S. F. Light has checked this determination. No data are available concerning its distribution in Mauritius. Records of *Reticulitermes lucifugus* (Rossi), the common European termite, from the vicinity of Boston were published in 1918. This does not seem to have spread far from its point of introduction. Another case that deserves careful study is the introduction of *Coptotermes formosanus* Shiraki into Hawaii some time prior to 1913 from China or Formosa. This species is surely very destructive to buildings in the cities, but published accounts do not indicate its invasion of the wild habitats in the Hawaiian Islands.

One possible exception to the general rule that foreign termites have not spread from the point of introduction into native habitats may be found in the case of *Heterotermes tenuis* (Hagen), a native of Brazil, the Guianas and Panama. This termite is reported to have been introduced into the island of St. Helena in 1840. Accounts of the damage to houses and furniture are vivid, but the invasion of native wild habitats has not been reported.

A careful study of the limiting factors of the distribution of various species of termites may ultimately enable us to predict the results of introduction, but up to date we have little evidence to support the idea that termites are extending their range or that they will be able to compete effectively with the native species in natural habitats if introduced from foreign countries.

ALFRED E. EMERSON
THE UNIVERSITY OF CHICAGO

HIGH ALTITUDE STRATOSPHERE OBSERVATIONS[1]

IN the November issue of the *Journal of the Aeronautical Sciences* for last year we[2] described a system of radiometeorography which had shown promise as a method of securing weather data at moderate altitudes—up to 20 kilometers. In undertaking this development we had in mind ultimately to construct equipment along similar lines designed to go to much higher altitudes to secure other information from the stratosphere, such as ultra-violet intensity and cosmic-ray data, using automatic radio recording.

The practicability of this idea has been well demonstrated by a record obtained from a sounding balloon with radiometeorographic equipment which we released on March 23 of this year. A 44-inch (uninflated) rubber balloon was inflated to give an ascension rate of nearly 500 meters per minute when carrying our 5-meter transmitter with associated equipment which weighed altogether approximately 1½ pounds. The atmospheric pressure record obtained is shown in the accompanying figure. The circles in the curve I each represent a pressure reading transmitted to the ground and punched in a paper tape by a recording radio receiver. These occurred at one-minute intervals. Occasional missed readings were caused by local "interference"—not failure of signal. The

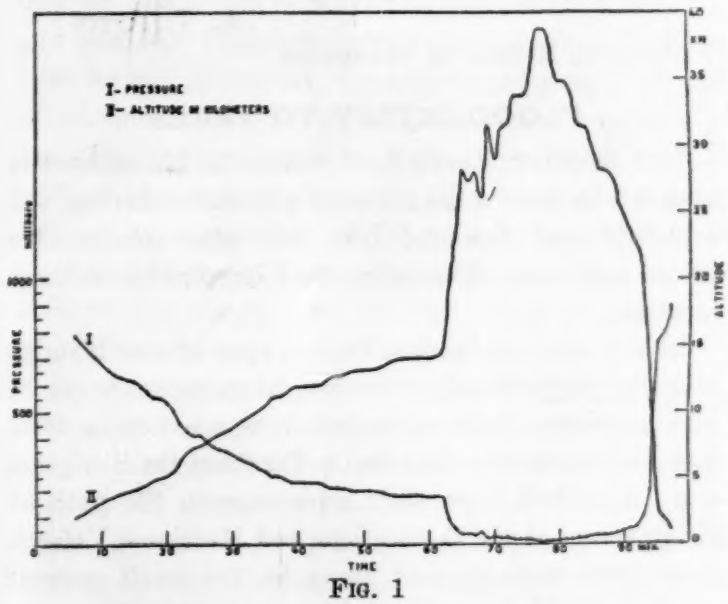

FIG. 1

minimum pressure recorded is 6 mm of mercury (8 millibars) which corresponds to an altitude of 38.7 kilometers or 127,000 feet. The transmitter also sent out signals which yielded an automatically recorded account of the temperature of the interior of the Cellophane inclosure which shielded batteries, oscillator and

[1] Publication approved by the director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] L. F. Curtiss and A. V. Astin, *Jour. Aero. Sci.*, 3: 35, 1935.

clock work from upper air temperatures. It was found that such an inclosure, as has been reported by Regner and Pfotzer,[3] remains above +35° C. throughout the ascent.

We succeeded in securing a record also of the falling apparatus, attached to a parachute, down to an altitude of about 1 kilometer, when it apparently fell below the horizon for our antenna. From the cessation of signals at this altitude we estimate that the apparatus fell about 50 miles from the receiver.

The sharp step in the pressure curve at about 61 minutes is probably caused by a sticking and sudden release of the pressure hand. The instrument seems to have recovered from this trouble at that point and functioned properly throughout the remainder of the ascension. This tendency to stick would have lowered the indicated altitude in any case, so that we feel fairly certain that the balloon reached an altitude above rather than below that indicated on the curve.

This ascension is of additional interest in view of the recent Russian ascension at Novosibirsk (reported in American newspapers on April 8) which reached a pressure of 4 millimeters of mercury and is claimed as a record for such ascensions. The corresponding altitude is 139,000 feet.

This work is being carried on with the cooperation of the United States Weather Bureau.

L. F. CURTISS
A. V. ASTIN
NATIONAL BUREAU OF STANDARDS

FLOOD INJURY TO TREES

THE receding March flood waters in Massachusetts have left in their wake not only physical suffering, soil depletion and financial loss, but also considerable severe and some devastating and irreparable damage to trees.

In any attempt to classify the types of tree injuries observed there would, of course, be many instances of overlapping. Some uprooted trees are now a total loss, resting on the river banks far from their original site. Snatched from their anchorage in the path of rising rivers of the Connecticut and Merrimac Valleys, these trees were carried along by the swift current causing untold damage to bridges and other structures as well as to cultivated land along the river banks. Trees which withstood the raging torrents of the flood and were not uprooted in some cases are also a total loss because of the severity of the injuries received. These injuries include the girdling of trees and the destruction of the cambium by the ice floes beating against the bark. It may be possible to save certain of these trees by bridge-grafting if proper methods are adopted. Frequently, injury from ice floes is limited to one side of a tree and the employment of sanitary, sterilizing and protective measures offers possibilities for saving these trees.

Pruning out of diseased, injured, twisted, gnarled and debris-filled smaller branches will assist tree owners in discovering the problems of repair on individual trees and will at the same time afford the trees opportunity for a more vigorous growth in many instances. Where some of the bark has been stripped from trees, care should be taken to cut back the remaining bark on the tree trunk to the limits of the loosened bark at which points the uninjured bark should be observed as being firmly attached to the supporting layer. After this preliminary cutting back of the bark has been accomplished, an attempt should be made to round out the edges of the debarked wound, leaving an oval wound, of which the longest diameter is approximately parallel with the grain of the wood. The polar extremities of the wound may be brought to points if feasible. Such a symmetrical wound not only contributes to the appearance of the repaired tree, but also it affords the maximum opportunity for wound-healing and recovery. A coating of shellac may be applied to the exposed edges of the cambium, following which treatments of the wound should be given with creosote and asphalt, for sterilization and protection, respectively. The creosote should be applied directly to the entire debarked, clean surface of the wound and the asphalt may later be spread over the same surface to form a rather thick, protective covering, which fits tightly at the edge of the wound. In most cases no excavation of wounds is necessary on flood-injured trees.

Still another type of injury suffered by trees as a result of the floods is injury from chemical or toxic materials which the floods engulfed in their swift currents. In some places a heavy deposit of crude oil settled, in varying degrees, over the landscape. It would appear that this oil was liberated into the rivers at some time during the height of the floods, since small evergreens which were considerably below the high level of the water escaped the sure death of the taller and now completely blackened and destroyed trees. Most of the taller evergreens affected by the oil can not possibly be salvaged as ornamental trees of the future. Many of the deciduous trees which were in a dormant condition during the floods, however, especially those with pendulous or weeping branches, were protected from complete destruction by the smaller branches acting as seines to catch the oil before it reached the larger branches and trunks. In such cases the smaller branches and twigs which are now dead should be promptly pruned out in order to eliminate the possibility of the oil's spreading to other parts of the tree during the warm weather.

[3] E. Regner and G. Pfotzer, *Phys. Z.*, 35: 779, 1934.

A rather sinister possibility of injury to trees in flooded areas, which at the present time may only be speculated, is injury from chemicals such as gasoline, which would leave no perceptible trace on trees, but which nevertheless might effectively kill all plants.

MALCOLM A. MCKENZIE
AGRICULTURAL EXPERIMENT STATION
AMHERST, MASS.

FISH MORTALITY

IN the issue of SCIENCE dated November 1, 1935, Mr. David Tomlinson reported a case of sudden death of fishes in a shallow pool under the title "Rare Aquatic Phenomena" and stated that the phenomenon has been "only recorded in a very few places throughout the world during the past 50 years." I may state that in the plains of India this phenomenon seems to be of frequent occurrence. In Calcutta, when the writer was working there, a sudden epidemic of fish mortality occurred in an acute form twice (and in mild form several times) in the same pool within five years (1926–31). Though on both occasions the epidemic was investigated and the results obtained were published, Mr. Tomlinson apparently does not seem to be acquainted with this happening. In 1926 it was investigated by Seymour Sewell,[1] who concluded that the cause of the epidemic was the sudden accumulation of CO_2 brought about by abrupt changes in the meteorological conditions. In 1931, when the phenomenon occurred again in a severe form, the writer of this note investigated its various aspects and published the results.[2] It was concluded that the epidemic of mortality in the pool was due to the complete exhaustion of dissolved oxygen in the bottom layers of the water as a result of the rapid decay of the accumulated organic matter there. The writer is therefore very much interested to learn that the cause of the catastrophe observed by Mr. Tomlinson in Connecticut, U. S. A., though only superficially investigated, was also associated with almost complete exhaustion of the oxygen content of the water.

HEM SINGH PRUTHI,
Imperial Entomologist
PUSA, INDIA

SCIENTIFIC BOOKS

INSECT MORPHOLOGY

Principles of Insect Morphology. By R. E. SNODGRASS. 667 pages, with 319 figures, the majority of which carry two to several illustrations. Published by the McGraw-Hill Book Company, Inc., New York and London. 1935. Price $6.00.

THIS is a volume of interest to zoologists as well as to entomologists. From the wealth of material it contains will be drawn a few samples of interest to both.

The work opens with a forty-page synopsis of the more general features of insectean embryology. In the Collembola, a primitive, wingless group which some authors set off as a class, cleavage of the egg is holoblastic. This is probably not the primitive type of cleavage for other insects as the Collembola are further peculiar in having but six segments in the abdomen, though otherwise their body-structure is insectean. In all other orders, excepting some highly specialized parasitic forms, the egg is loaded with a dense yolk which conditions a meroblastic or superficial cleavage. Cleavage is further evidenced distinctive in the early differentiation of the germ cells at the posterior pole. As a result, insect eggs have been one of the favorite subjects of study by students of the differentiation and migration of these cells. In many insect eggs they can be easily recognized as they are slightly different from the surrounding cells in structure of nucleus and in the presence of dark-staining granules.

Gastrulation, because of the dense yolk, deviates from the terms of the general gastrulation theory, for in most insects the endoderm is formed from anterior and posterior rudiments which arise at the ends of the mesodermal rudiment. In a few instances a strand of endodermal cells may connect these temporarily. Usually the strand cells migrate very shortly into the yolk and become vitellophags. The coelomic sacs are formed by a splitting of the mesoderm, which later by fusion form a haemocoele. The body-wall of the embryo is a single layer of cells which later become glandular and secrete the exoskeleton.

In the basic plan of the insect body Snodgrass, following Holmgren and Hanström, takes the view that it is composed of a preoral or prostomial region followed by eighteen segments enervated from as many pairs of ventral ganglia and ending in a periproct (telson in the Malacostraca) which bears the anus. Thus the procephalon, which bears the compound eyes and antennae, has been derived from a prostomial region enervated from a supraoral brain (protocerebrum plus deutocerebrum). The tritocerebrum is a distinct pair of ganglia arising laterad of the oral opening and with a commisure behind the mouth. The tritocerebrum enervates the oral and labral regions and the second antennae (embryonic). By this theory,

[1] *Jour. Asiatic Soc. Bengal*, 22: pp. 177–201, 1926–27.
[2] *Internat. Rev. Hydrol. Hydrog.*, 26: 1932.

the tritocerebral ganglia are the first pair of ventral ganglia posterior to the oral opening, though usually associated with the sides of the supraoral brain. If ever segmentally distinct in the past as a segment with its paired appendages the second antennae, the tritocerebral segment has become completely fused with the prostomial region. Behind the tritocerebral segment are three poststomial segments, mandibular, maxillary and labial, which are enervated from three pairs of ventral ganglia fused into the "suboesophageal ganglion." The thorax contains three segments, each carrying a pair of legs; the abdomen is composed of eleven segments plus the periproct or telson. Counting the prostomial region and periproct as "segments," the Holmgren theory accounts for twenty segments in the arthropod body instead of twenty-one, as usually stated.

Snodgrass derives the Insecta from some Chilipod-like ancestor through the loss of abdominal legs. He gives a painstaking discussion of the evolution of the attachment of the legs in the Chilopoda and related forms, and in such primitive insects as the Protura, Collembola and Thysanura. He presents much evidence for the theory of Heymons and Börner that each side or pleural region of a thoracic segment has been evolved by a flattening out of a subcoxal joint of a leg. The flattened subcoxa evolved into a brace between tergum and sternum, gained attachments to these and was eventually differentiated into the episternum, epimeron and trochantin of the side of the thoracic segment. Thus arose the pleurite and the definitive joint between the insectean coxa and the body.

The attachment of the wings has always interested Snodgrass and has been a subject which has attracted little attention from other anatomists. He presents the theory, which is generally accepted, that the wings are paranotal expansions of the tergum. This involves a study of their growth and attachments, out of which has come confirmation of and additions to the recent developments in the theory of the homologies of wing veins from order to order.

The wing veins have been given a thorough study in which much evidence hitherto overlooked by other students of the subject has been introduced. The new evidence is from the association of the veins with the several small sclerites in the wing hinge. Snodgrass recognizes, precosta (in early fossil insects), costa, subcosta with two branches and radius with five branches. Media in the archetype had two main branches, *media anterior* (MA), which had two branches (MA_1 and MA_2), and *media posterior* (MP), which has persisted in modern forms with four branches (M_1, M_2, M_3 and M_4). In Ephemerida both branches are retained. In Odonata only MA is retained. In all other modern winged insects MA is lost and MP (with MA lost now called M) with its four or fewer branches is retained. Cubitus has two branches (Cu_1 and Cu_2), but the fork is in the base of the wing. As has been shown by Tillyard and others, Cu_1 is two-branched. Its two branches are Cu_1 and Cu_2 of the Comstock-Needham system for the orders Hymenoptera, Trichoptera and Lepidoptera, while the proper Cu_2 of the system followed by Snodgrass in these orders is first anal in the Comstock-Needham system. In other orders, Snodgrass uses the term postcubitus for the first anal of the Comstock-Needham system. Next are the vannal veins (iV to nV), which may vary from one to twelve in number and are anal veins in the Comstock-Needham system. Behind these in the jugal membrane may occur one or two jugal veins (J).

In various papers and summarized in this work, Snodgrass has given us what is probably the best analysis of the homologies of the external genitalia yet published. These chapters are of particular interest to entomologists, as it has been found that these organs, especially in the male sex, carry the most reliable structural characters for species determination in taxonomic work. The general evidence is that the female of the archetype insect bore an ovipositor near the tip of the abdomen with which she secreted her eggs in crevices and in later evolution with its better development in soft tissues. This organ on the eighth and ninth segments of the abdomen became rudimentary or entirely disappeared in some later forms, while in others, as in the higher Hymenoptera, it was modified into a sting or developed into a needle-like drill as in species ovipositing in timber. Ovipositors in many groups give characters separating species, but in the majority of insects the first parts examined by the experienced taxonomist to determine the species are the male genitalia. The problem of the homologies of the parts of the male external sexual organs, which vary from species to species in the majority of the six hundred thousand insects described, was one of such difficulty that it was one of the last areas of insect anatomy reviewed by the author in preparation for the writing of the present volume. However, based on work already done by embryologists and morphologists, he appears to have brought the apparent conflicts into agreement and gives us a chapter which is probably a correct homologization of these parts.

The presentation of material is from the evolutionary or comparative anatomy standpoint which introduces matter dealing with generalized forms and connecting links. Consideration of function is interwoven with the discussion of structure. The use of the two sources of evidence is most noticeable in the author's analysis of skeletal parts all of which are identified by and related to their proper musculature. The

study of muscles in relation to skeletal parts is the approved method of homologization of the parts of the exoskeleton. Because the exoskeleton is completely resecreted after each ecdysis evolutionary changes in skeletal areas occur in bewildering variety. Primitive sutures fuse and primitive plates later become sutured. The attachments of muscles are frequently more reliable evidence of homology than are the edges of sclerites. They are attached to the inside of the cellular wall, which in some ways is a more stable condition phylogenetically than that of the exoskeleton, which is merely a hardened secretion.

The discussions in general are confined to adult insects, although very few of the insects that the professional entomologist meets in the field are adults. At times the author touches on the structure of larval stages, but in no part of the book does he discuss pupal stages and metamorphosis. Because of lack of space in even six hundred pages, Snodgrass has been compelled to omit the many curious and unusual specializations of structure found in all orders of insects.

One of the general characteristics of the Insecta is the morphological adaptability of the group. At each of the several or many ecdyses the body wall becomes embryonic, not one embryonic period to an ontogeny but several, in any of which profound changes of structure may be introduced. On this substratum of repeated embryonic periods has been built the supermechanism of complete metamorphosis. Hardly anything in the general phenomenon of organic growth is more strange than the development of the fly's head, inside out, in a sack opening into the mouth cavity of the maggot. On pupation the sack everts which brings the various head organs into position on the outside as found in the adult. The high development of special larval organs which in a few days' time are digested and have their substance rebuilt into the adult organs, is another commonplace of the protean adaptability of insects. The study of the great variety of adult and larval organs is a biological goldmine. It is these high specializations which Snodgrass is compelled to omit. These omissions suggest to the reader the extent of the problems of insect anatomy and more than anything else impress upon him that this work deals only with the more far-reaching fundamentals.

An elaborate terminology has been avoided, and such terms as are used have been chosen as far as possible to agree with the terminology of current writings on the subject. The volume has freshness of ideas and style, due largely to the fact that nearly every point discussed has been studied in actual insect material by the author himself, who has devoted his time almost without interruption for over thirty years to a study of insect anatomy. Further, it is well written from cover to cover. It is not a volume expanded from a few chapters of lecture notes, but the last chapter is as carefully written as is the first.

The illustrations are a striking feature of the work, as the majority are by the author, while those borrowed have all been redrawn in a style uniform throughout the volume. It is this remarkable ability to see things, then to draw them in a superb style that makes an outstanding anatomist. Snodgrass is one land zoologist who did not rush to the seashore, but who by patient exploration found greater riches in the common insects all about on land. This ability to see the riches in the common and abundant, to organize and interpret the commonplace is one of the characteristics of genius.

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THE PUNCHED-CARD METHOD

Practical Applications of the Punched Card Method in Colleges and Universities. Edited by G. W. BAEHNE. xxii + 442 pp., 7 by 10 inches. Columbia University Press, New York, 1935. $4.50.

THE principle of the punched-card method of tabulation goes back to the beginning of the nineteenth century when Babbage invented his "analytical engine." The modern method as used on the machines of the International Business Machines Corporation has grown out of the perfections introduced by Dr. Herman Hollerith. For fifty years the punched-card method of tabulating and accounting has been used with increasing success by government and business. More recently it has found application in colleges and universities, in administration offices as well as for research purposes.

The tabulating card consists of 80, or 45, numbered equidistant columns, each having twelve punching positions. These are numbered from zero to nine, with two additional positions at the top of the card. With the use of an electric punching machine having a keyboard of twelve keys the operator can punch holes in any punching position of any column. In each application the card is divided into fields consisting of a single column or of groups of columns each of which is to contain a particular type of information. Any information that can be expressed in numbers can be so recorded, if necessary by special codes.

The two essentials are a sorting machine and a tabulator. In all cases the operating principle is the same, with different details in different machines. In the case of the sorter:

> A tabulating card, acting as an insulator, passes between a wire brush and a brass roller. A hole punched into the card causes the brush and the brass plate to make contact and closes an electric circuit which, in

turn, actuates an electro-magnet. In the case of the sorting machine this magnet opens a chute along which the card slides until it falls into the proper receptacle.

In the tabulating and accounting machines a row of brushes, corresponding to the columns of the card, takes the place of the single brush. . . . The contacts, similarly made, energize counters or print banks.

Because they are operated by electrical rather than by any mechanical means, flexibility is an inherent feature of all electric tabulating and accounting machines. To attain this flexibility the more complex machines employ a plugboard which is similar in principle to a telephone switchboard.

A tabulator with four counters can, with an automatic control device, carry individual items, sub-totals, intermediate totals and grand totals in different counters. It prints at will each item or total as it is produced on the counters.

The original tabulator could perform additions only. In order to make the machine perform a subtraction it was necessary to feed into the machine a card on which the complement of the number to be subtracted was punched. A more recent machine is the direct subtraction tabulator.

Auxiliary machines which may be of major importance in some applications are the "verifier," the "reproducing punch," the "gang punch" and the "automatic interpreter," the last being a device for *printing* on the card the data already punched.

Among the important newer types are the "alphabetic punch," the "automatic summary punch" and the "multiplying punch." The summary punch produces summary cards during the process of tabulation. It eliminates the manual preparation of such cards from the printed record. The multiplying punch performs direct multiplications of numbers up to eight digits; it can be made to perform operations of the type $A \pm (B \times C)$.

The power of the Hollerith method, in addition to its flexibility and reliability, is the superhuman speed with which the machines operate. These speeds vary with different designs of the same machine. The following are quoted: A sorter will handle 400 cards a minute, the tabulator 150 cards a minute. The multiplying punch is slow compared with these speeds. It performs 1,500 operations per hour for 3-digit multipliers, and 740 per hour for 8-digit multipliers.

Only the first twenty pages of the book deal with the development and principles of the method, and with descriptions and illustrations of various tabulating machines and special devices. The bulk of the volume consists of thirty-eight chapters on various applications, grouped into nine parts.

Of particular interest is the part on miscellaneous research applications by Professors Hooton (anthropology), Eckert (astronomy), Spengler (economics), Fletcher (literature) and Johnson (social science). This part and that on methods of solution of statistical problems give, more so than the remainder of the volume, an insight into the great variety of possible applications of the Hollerith machines. They show that the machines can solve problems of almost any description. An experienced user of the machines has learned to adopt his procedure to the types of operation that the machines will perform. An interesting example of this adaptation is the Mendenhall-Warren-Hollerith correlation method, by which the coefficients of the normal equations in the method of least-squares are formed with a sorter and tabulator only. These coefficients are the sums of products of the coefficients of the observation equations, yet no direct multiplication is performed.

The chapter on astronomy by Eckert is the most tersely written article of the collection. It covers a wide range of applications in this field. It is regrettable that this article does not give more details. Due credit is given to Comrie's pioneer work in this field. Fletcher's chapter on applications in literature describes the use of an alphabetic punch in the construction of word indices and of concordances, an excellent use of the Hollerith method.

Every one reading this book, wholly or in part, will recognize that it has excellent qualities. Almost every single article is suggestive, interesting and worth reading. The book as a whole, however, hardly deserves such a favorable comment. There is too much irrelevant material; there are too many applications of the same elementary type. It is the reviewer's impression that the editor could have welded these thirty-eight articles into a smaller volume giving more condensed information.

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REPORTS

PRINCIPAL DECISIONS CONCERNING NOMENCLATURE MADE BY THE SIXTH INTERNATIONAL BOTANICAL CONGRESS, AMSTERDAM (1935)

(1) GENERAL acceptance of the text of the "International Rules of Botanical Nomenclature," ed. 3 (1935), as representing the decisions of the fifth International Botanical Congress, Cambridge (1930).

(2) Special acceptance of the date, January 1, 1935, recommended (instead of January 1, 1932) by the editorial committee of the "International Rules," ed. 3, (1935) as the starting-point for obligatory Latin

diagnoses of new groups of living plants (Bacteria excepted).—*Syn. Prop.* 29, Art. 38.

(3) Addition to Art. 20 of a paragraph to the effect that the two volumes of Linnaeus, "Species Plantarum," ed. 1 (1753) are treated as having been published simultaneously.—*Syn. Prop.* 16, Art. D 20.

(4) Treatment of provisional names (*nomina provisoria*) as not validly published.—*Prop. Brit. Bot.* (1929), 16, Art. 44; Briq. *Rec. Syn.* 41, Art. 37 ter; amended wording, excluding the words *"seu eventuale."*

(5) Treatment of alternative names (*nomina alternativa seu eventualia*) as validly published. Example: The names ***Cymbopogon Bequaerti*** De Wild. and ***Andropogon Bequaerti*** De Wild., proposed simultaneously as alternative names for a new species described in ***Bull. Jard. Bot. Brux.*** vi. 8 (1919), are both treated as validly published.

(6) Replacement of Art. 54, paragraph 2, by a paragraph to the following effect:

"When, on transference to another genus, the specific epithet has been applied erroneously in its new position to a different plant, the new combination must be retained for the plant on which the epithet was originally based, and must be attributed to the author who first published it."—*Syn. Prop.* 39, Art. 54, amended wording.

(7) Textual amendment of Art. 60. The second sentence to read as follows:

"The publication of an epithet in an illegitimate combination must not be taken into consideration for purposes of priority, except as indicated under Art. 61."—*Syn. Prop.* 46, Art. A 60 [This brings the text of Art. 60 into conformity with Art. 61].

(8) Addition to Art. 61 of a paragraph to the following effect:

"When an author simultaneously publishes the same new name for more than one group, the first author who adopts one of them, or substitutes another name for one of them, must be followed."—*Prelim. Opin.* 18, Art. A 61 [The same principle of selection is already embodied in Art. 56, where two or more names have been published simultaneously for the same group].

(9) Addition to Art. 70 of a note to the following effect:

Note 2 bis. "The liberty of correcting a name must be used with reserve, especially if the change affects the first syllable, and above all the first letter of the name."

Example: The spelling of the generic name *Lespedeza* must not be altered, although it commemorates Vicente Manuel de Céspedes.—*Syn. Prop.* 52, Art. D 70; *Rhodora,* xxxvi. 130–132, 390–392 (1934).

(10) Rec. XLIII amended to read as follows:

"Specific (or other) epithets should be written with a small initial letter, except those which are derived from names of persons (substantives or adjectives) or are taken from generic or vernacular names (substantives or adjectives)."

Additional examples: *"Schinus Molle* (Peruvian vernacular name), *Astrocaryum Tucuma* (Brazilian vernacular name)."—*Syn. Prop.* 55, Rec. B XLIII.

(11) Art. 72, Section (1), to be replaced by the following: "A Greek or Latin word adopted as a generic name retains its classical gender. In cases where the classical gender varies, the author has the right of choice between the alternative genders. In doubtful cases, general usage should be followed.

"The following names, however, whose classical gender is masculine, are treated as feminine in accordance with historic usage: *Adonis, Orchis, Stachys, Diospyros, Strychnos. Hemerocallis* (m. in Sp. Pl.: Lat. and Gr. *hemerocalles* n.) is also treated as feminine in order to bring it into conformity with all other generic names ending in *-is."—Syn. Prop.* 58, Art. C 72.

(12) (a) Rejection of the principle of *Nomina specifica conservanda* by a majority of 208: 61.—*Syn. Prop.* 18, Art. A 21, 21 bis.

(b) Appointment of a Special Committee to draw up a list of names of economic plants in accordance with the International Rules. This list may remain in use for a period of ten years.

(13) A resolution was passed recommending the adoption by botanists of the standard-species (*species lectotypicae*) of Linnean generic names printed in *International Rules,* ed. 3, pp. 139–143, unless there is clear reason for rejecting any species in favor of another. Any changes considered desirable should be communicated to the Secretary of the Special Committee for Phanerogamae and Pteridophyta, Miss M. L. Green, The Herbarium, Royal Botanic Gardens, Kew.

(14) The list of Standard-Species of Nomina generica conservanda printed in *International Rules,* ed. 3, pp. 143–146, was referred to the Special Committee for Phanerogamae and Pteridophyta.

(15) The lists of *Nomina generica conservanda proposita* printed in *International Rules,* ed. 3, pp. 118–138, *Synopsis of Proposals,* pp. 66–73, and *Preliminary Opinions,* p. 25, were referred to the appropriate Special Committees appointed at Amsterdam.

(16) Acceptance of the list of *Nomina familiarum conservanda* printed in *Syn. Prop.* pp. 64–65.

(17) The following four resolutions concerning Algae were adopted:

1. In describing new species of Algae special importance should be attached to the provision of illustrations and to maintenance of cultures of the species concerned.

2. The desirability of adopting further monographs as the starting-points of particular groups of Algae, as in the *Oedogoniaceae,* should be investigated.

3. A list of *Nomina dubia* of species, genera and families should be prepared, and also lists of *Nomina conservanda* and *rejicienda* of genera and families.

4. The desirability of retaining the Latin language for diagnoses of new Algae should be investigated.

(18) All proposals concerning mycology, submitted to the Amsterdam Congress, were referred to subcommittees to be appointed by the Special Committee for Fungi.

(19) Additions concerning paleobotany to be made to the rules and recommendations for the following objects:

1. To recognize as taxonomic groups, organ genera and artificial or form genera.

2. To ensure that the names originally given to detached organs or parts of plants shall only be used in their original signification, and shall not be employed in the designation of different organs, or of the plant as a whole.

3. To provide for the naming of an entire plant when it has been possible to reconstruct it by the association of its different organs.

4. To define how the names of the artificial genera are to be used.

5. To set up a permanent committee to consider the interpretation of the rules; to adjudicate in cases of dispute or difficulty; to draw up lists of *Nomina generica conservanda;* and to make such further recommendations as may prove necessary, including rules for the determination of types.

(20) Appointment of a Special Committee to report on the effects of the adoption of the proposed Art. A 19 and Appendix "IX," dealing with the rejection of certain works.—*Syn. Prop.* pp. 15, 77–80.

T. A. SPRAGUE

SPECIAL ARTICLES

THE EFFECTS OF PHYSIOLOGICAL AGENTS ON ADULT TISSUES IN VITRO[1]

THE dormant state of adult tissue cells has been studied by observing the effect of various agents upon the initial growth of the adult tissue *in vitro.* Fresh pieces of adult tissue (mainly chicken aorta) have been treated with these agents previous to planting in a dilute plasma medium. The resulting effects on the lag period preceding growth and on the rate of the initial growth have been recorded.

Furthermore, the physiological state of the cells has been studied by treating active cultures of adult tissue cells with various "factors" obtained from normal blood plasma.

A study of over 40,000 pieces of tissue has given the following results:

(1) The lag period preceding the first visible growth of fibroblasts from aortas of one-year-old chickens was normally three to five days (as contrasted with a few hours for embryo tissue).

(2) The lag period of aorta tissue from five- or six-year-old chickens was about the same as that of the one-year chickens, but the average rate of initial growth was 46 per cent. faster for the older tissue.

(3) Plasmas from the older chickens induced growth 9 per cent. sooner than young plasmas. The initial growth rate was 50 per cent. faster in two-year plasmas than in one-year plasmas; but it was 21 per cent. slower in the five-year plasmas than in the one-year plasmas.

(4) Trypsin stimulates the growth of adult tissue. Digestion of the tissue with trypsin previous to planting in a plasma medium reduces the lag period to less than one day and accelerates the rate of the initial growth. This has been repeated many times, not only on artery tissues, but also on liver, thyroid and some tumors. Papain stimulates in the same manner.

(5) The stimulating action of trypsin was found to result from the proteolytic digestion of the tissue. This apparently removed an inhibitor contained in the tissue. The digestion fluid after this treatment was found to contain an inhibitor which could be precipitated out. This "tissue inhibitor" is destroyed by heat. It seems to be widely distributed in normal adult tissues (and in tumors). It presumably plays a rôle in restraining growth in adult animals. It appears to be produced by cells in tissue culture.

(6) Embryo extract and spleen extract had little effect on the initial growth of adult tissue. Both contain inhibitors. Pituitary growth hormone was slightly stimulating, particularly in the presence of serum.

(7) Blood plasma contains a growth stimulant, the "A factor." It is present in a concentration more than adequate to induce growth *in vitro.* It is also present in tissues, in lymph, in urine, in serum and in the ultrafiltrate from serum. Serum ultrafiltrate is prepared routinely for use in washing cultures and as a basic medium in our sterile perfusion pump.

[1] These investigations have been supported by grants from the Josiah Macy, Jr., Foundation.

The A factor produces a definite reduction in the g period and a stimulation of the initial growth. We ave obtained no growth in its absence, and it appears urthermore to be needed by cells in a resting condi-ion. It has a small molecular size. Electrodialysis hows it to be an acid. It can be precipitated with alcium or copper with subsequent recovery of activity. t is only slowly destroyed at 100° C., providing the H is neutral.

Thus the dormancy of adult tissues appears to in-olve a balance between the non-diffusible "tissue nhibitor," on the one hand, and the stimulating A actor and proteolytic enzymes on the other hand (and robably other agents).

The physiological condition of adult tissue cells eems similarly to involve a balance between certain ormone-like "controlling agents." There are at least our of these in plasma, the A, B, C and D factors.

(8) The first of these, the A factor, is not only a timulant, as mentioned above, but it appears further-more to be needed by dormant cells. If a culture of dult fibroblasts is washed repeatedly with serum ltrafiltrate (containing the A factor) the B, C and D factors are thereby removed without depriving the ells of the needed A factor. The cells then become lear, stellate and free from fat granules. They can e kept in a healthy state indefinitely, merely by semi-weekly washing with serum ultrafiltrate.

(9) When one of these cultures of clear cells is reated with a solution containing the B factor (ob-ained from chicken plasma or dog serum) the cells ecome filled with fat granules. These can be seen in hours and are very conspicuous in two or three days. his process can be reversed. Repeated washing with erum ultrafiltrate results in a complete absorption of he fat granules. Thus the B factor is an agent which auses the cells to produce fat granules—but it does ot produce degeneration.

(10) The C factor, however, produces degeneration ut does not produce fat granules. It is closely asso-iated with the B factor. This degeneration is not eversible.

(11) There is also evidence for a "D factor" which roduces cohesiveness between fibroblasts. The cul-ures which have been washed with serum ultrafiltrate ontain independent isolated cells. On the addition f certain fractions these cells coalesce to form the sual reticulum.

(12) Segments of chicken innominate arteries were ncubated in solutions containing the B factor. Frozen ections stained with Scharlach R showed that fat had een deposited in these arteries *in vitro*. The fat was en as a thin layer along the intima with scattered roplets in the adjacent media. This same distribution f fat occurs spontaneously in chicken arteries *in vivo*. Details will be published elsewhere. Further work is in progress.

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BACTERIOLOGIC EXPERIMENTATION ON THE GUINEA PIG FETUS

ALTHOUGH bacteriologists are continually in search of new and more adaptable experimental animals, the possibility of using the fetus for bacteriologic studies appears to have been almost entirely overlooked. Most of the recorded investigations dealing with experimental fetal infections have been based on the passage of the infectious agent from maternal to fetal circulations through the placenta. Obviously, in such experiments there can be no control of the time of effective fetal inoculation or of the amount of inoculum which actually reaches the fetus. That direct manipulation of the mammalian fetus is possible, however, has been shown by Bors,[1] Wohlwill and Bock,[2] and others. Their studies have been concerned chiefly with developmental processes and pathologic changes. The latter authors studied particularly the cellular type of response of the guinea pig fetus to directly inoculated chemical and bacterial irritants.

The potential value of the fetus as an experimental animal for bacteriologic purposes is based on its inherent sterility and on the possibility that the fetus may present useful variations in susceptibility to certain disease agents in comparison with the postnatal representative of the same species. This possibility may be inferred from the fact that the fetus differs markedly from the postnatal animal not only in size and structure, but in physiological and biochemical processes as well. In order to investigate this possibility and to learn some of the technical applications and limitations in the use of the fetus as an immediate experimental animal for bacteriologic research, we[3] have inoculated fetal guinea pigs *in utero* with six infectious or toxic agents. They were selected to represent a wide range of host-parasite relationships, *viz.*, the poliomyelitis virus, for which the monkey is at present the only susceptible experimental animal; the vaccinia virus, which finds a relatively resistant host in the guinea pig; diphtheria toxin, for the study of which the guinea pig may be said to be the classic experimental animal; two strains of the tubercle bacillus (H37 and BCG), representing, respectively, bacteria virulent and relatively non-virulent for guinea pigs and other animals; and the submaxillary gland

[1] E. Bors, *Archiv. f. Entwick. d. Org.*, 105: 655, 1925. *Ibid., Deutsche Ztschr. f. Chir.*, 203–204: 669, 1927.

[2] F. Wohlwill and H. E. Bock, *Virchow Archiv. f. path. Anat. u. Physiol.*, 291: 864, 1933.

[3] *Am. Jour. Pathol.*, in press.

virus of guinea pigs, a virus natural to that animal and latent in spontaneous infections.

The most favorable fetal age for such inoculations was found to be 30–35 days. Earlier than this the fetuses are too small to be inoculated directly; older fetuses are more likely to be aborted. Since the gestation period of the guinea pig is from 60 to 65 days, inoculation of the fetuses about the thirtieth day provides about a month of possible intrauterine development, following inoculation. Fetal inoculations were made principally intracerebrally by needle puncture through the maternal uterine wall and fetal membranes, after surgical exposure under ether anesthesia. Experiments were terminated usually by delivery of the fetuses through cesarean section after an appropriate incubation period, although some of the mothers were allowed to go to term in cases where a longer experimental period was preferred.

The poliomyelitis virus did not affect the vitality of the fetuses nor was there any determinable histologic reaction following intracerebral inoculation. Two attempts at serial passage, one through eight transfers at 5-day intervals, the other through four transfers at 10-day intervals, were also unproductive. The passage material proved non-infectious for monkeys at the end of each series. Thus the known resistance of the species to this virus obtained likewise in the fetus under the conditions provided.

The guinea pig fetus proved to be particularly susceptible to the vaccinia virus in contrast to the characteristically sluggish reaction of mature guinea pigs. Quantities of virus that caused scarcely a visible reaction in postnatal animals were sufficient to evoke wide-spread cutaneous and visceral lesions and even death in the fetus. Identification of the virus in fetal tissues was made by intradermal tests in immune and non-immune rabbits. Although the virus was administered to the fetuses intracerebrally, the fetal brain usually contained little virus at the termination of the experiment. The kidneys consistently gave high titers, and lung and skin lesions likewise were dependable sources of virus. The virus was recovered from only two of ten specimens of heart blood. Nine serial passages through fetuses did not alter the properties of the virus in respect to the rabbit and the guinea pig.

Although the guinea pig is a classic test animal for diphtheria toxin, many workers have held that very young animals are relatively more resistant. In our experiments, fetal guinea pigs reacted acutely to the toxin, and the minimal lethal doses for fetal and postnatal animals were about the same when calculated on the basis of toxin per gram body weight.

We have found the fetal guinea pig delicately responsive to small dosages of the tubercle bacillus given intracerebrally. Both the virulent strain (H37) and the allegedly non-virulent strain (BCG) caused extensive and progressive pathologic changes comparable to those seen in adult animals following the inoculation of virulent organisms. H37, however, was effective in smaller amounts and disseminated with more facility. Metastatic lesions, demonstrable grossly and microscopically and containing acid-fast organisms, were commonly found in the spleen, liver and lung following inoculation of small quantities (0.01 mgm) of H37 and larger dosages (0.1–1.0 mgm) of BCG. Death regularly resulted in all the fetuses injected with H37 and in those receiving the larger quantities of BCG. Recovery of BCG on media was irregular, and fetus-to-fetus transfer was not accomplished in the few attempts made.

The submaxillary gland virus disseminated from the cerebral site of inoculation much more widely in the fetus than in new-born animals, and cellular inclusions were numerous in various organs, particularly in the meninges, liver and placenta. It is of theoretical interest that the fetuses of mothers immune to the virus were just as susceptible as those carried by non-immune mothers and were readily killed *in utero* by the action of the virus.

We believe that both the practicability and potential value of bacteriologic experimentation on the mammalian fetus are established by these experiments. The principal difficulties encountered are those associated with the problem of inoculating the fetus without disturbing gestation, and the problem of following the progress of the infection after inoculation. By using fetuses at the optimal age, one can largely avoid abortions; experience with the particular virus and animal, in preliminary tests, will be the guide in judging dosages and incubation periods. The obvious technical advantage in the use of the fetus is that it is inherently sterile and occupies an environment of constant temperature and nutrition. When there are several fetuses in the litter an excellent opportunity is provided for controls and for a graded series of the inoculum. In our experience there has been no transfer of inoculum from one fetus to another within the same litter. A point of interest in such work is that the fetus *in utero* may tolerate more severe pathologic changes than are compatible with life in the outer world. So long as the placenta is intact the fetus may survive in the entire absence of brain, lung and other organs essential for independent existence. Thus the fetus may provide for observation more extensive lesions than could occur in the living postnatal animal. In our studies, pathologic changes characteristic for the agent were induced in each case, except with the poliomyelitis virus, and the range of reaction, dependent on dosage, varied from

faintly perceptible lesion to extensive tissue destruction and death.

Cultivation in tissue culture and in the chorioallantoic membranes of the chick has demonstrated that under such conditions embryonic tissue is peculiarly susceptible to a variety of infectious agents, particularly filterable viruses. That a similar situation exists with respect to the mammalian fetus *in utero* may be inferred from our studies. Certainly the susceptibility of the guinea pig fetus may exceed that of the postnatal representative of the same species, as we have seen especially in connection with the vaccinia virus. It is reasonable to expect also that fetal reactions to infectious agents will be found in certain cases to differ not only in degree but also in kind. In these respects, then, the fetus may be said in effect to constitute a new experimental animal for bacteriologic procedures.

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THE ISOLATION FROM COTTONSEED OIL OF AN ALCOHOL RESEMBLING ALPHA TOCOPHEROL FROM WHEAT-GERM OIL

EVANS, Emerson and Emerson have reported the isolation from wheat-germ oil of an alcohol, alpha tocopherol, having the properties of vitamin E.[1]

The same procedure has been followed in the preparation of the corresponding alcohol from cottonseed oil. Olcott[2] has demonstrated that a biologically potent concentrate could be prepared from cottonseed oil. Although this oil has only 0.7 per cent. nonsaponifiable matter, as compared with 5.0 per cent. for wheat-germ oil, the commercial production of cottonseed oil makes it a readily available source material.

Four allophanates were isolated:

(1) m.p. 240°—regenerated alcohol biologically inactive as vitamin E.
(2) m.p. 158°–160°—regenerated alcohol, biologically active, believed to be identical with alpha tocopherol.
(3) m.p. 134°–135°—regenerated alcohol biologically active. Further investigation to be made.
(4) m.p. 80°—regenerated alcohol biologically inactive.

The 158°–160° allophanates from cottonseed oil and wheat-germ oil appear to be identical for the following reasons: (1) The two compounds have the same melting point; (2) There is no depression in mixed melting points; (3) Both compounds exhibit a maximum absorption in the ultra-violet between 2,900 and 3,000 Ångstrom units; (4) The alcohols regenerated from the two allophanates show similar biological activity.

An attempt is being made to isolate one or more of these compounds from a lettuce-oil concentrate.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A FURTHER IMPROVED PROSPECTING PICK

BROWN described[1] an improved prospecting pick as ". . . a perfect tool of the kind, of drop forged highest grade 85 carbon tool steel, with a perfect eye extended so as to secure the full purchase power of the handle. . . ." The writer thoroughly tested one of these picks on various formations in the Blue Ridge and Massanutten mountains in Virginia in the summer of 1932. We agree with Brown that the pick has good dimensions and balance, and that it is a serviceable tool. It may be all that is desired for certain kinds of work, but "perfect" is a descriptive term which should be rarely used.

We believe we have improved upon this perfect tool by applying a relatively small amount of a very hard alloy of cobalt-chromium-tungsten,[2] which serves as the cutting or digging edge for both the spatula and pointed end of the pick. On the point of the pick the alloy was applied only to the outer triangular face, the one opposite the handle. On the spatula end only the outer face was treated, and here the hard-facing material was carried to the chisel point. The location of the hard-facing material on the ends of the pick in this fashion resulted in a saving of material—approximate thickness 1/16 inch—and also made the

[1] H. M. Evans, O. H. Emerson and G. A. Emerson, *Jour. Biol. Chem.*, 113: 319, 1936.
[1] B. Brown, SCIENCE, 75: 291, 1932.

[2] H. S. Olcott, *Jour. Biol. Chem.*, 107: 471, 1934.
[2] Haynes Stellite is the trade name applied to an alloy of cobalt-chromium-tungsten. One pick was very kindly modified, as described, by the Haynes Stellite Company, Kokomo, Indiana.

tool self-sharpening. This method of applying hard-facing material to but one face is said[3] to have worked very well with other digging parts, such as power shovel teeth and plowshares.

We decided upon simulated rather than actual field experiments in order that we might perform as nearly as possible exactly the same routine with the two picks, since it can readily be appreciated that manual digging might easily have resulted in serious errors in a comparative study of the wearing qualities of a modified and an unmodified Brown pick.

A hole was bored through an extension of each pick handle 36 inches from the pick end and a round iron rod of slightly smaller diameter passed through the holes and securely fastened to supports in such manner that the picks could only move up and down. The picks could then be lifted and allowed to fall freely through equal and controlled distances upon selected objects. The lifting and release of the picks was secured by the revolution of two eccentrics of the same size fastened to an axle which was geared to a one-fourth horsepower motor. The end of the pick handle farthest removed from the head was depressed as the eccentric was revolved by the motor and the pick elevated, then suddenly released as the eccentric continued its revolution, and as soon as one pick was released for its downward stroke the other was quickly elevated. Speed-reducing gears were introduced between the motor and the revolving shaft, thereby regulating the number of strokes delivered by each pick to twenty-six per minute. The length of arc through which the pick points rose and fell was approximately seven inches. A counter was attached to the shaft and each complete revolution of the shaft, and therefore the number of strokes delivered by each pick was automatically recorded.[4]

A total of eight thousand strokes were delivered by each end of each pick, distributed as follows: Alberene (a soft stone)—1,000 strokes; old brick—1,000; sandstone—1,000; concrete I (interior of a broken block)—1,000; concrete II (surface of U. S. Highway I)—3,000; polished, fine-grained white marble—1,000. The digging operation was interrupted after each five hundred strokes and the specimen turned so that each pick now dug where the other had been digging.

Neither pick showed much sign of wear after impact upon alberene and old brick, but beginning with sandstone a decided difference in the two picks was observed. The pointed end of the original Brown pick quickly became blunted and rounded off so that its effectiveness was materially lost and could only be restored by resharpening. At the same time and under the same working conditions the hard-faced pick became self-sharpening, the alloy showed no evidence of wearing and only the steel undercoat wore away. The results were even more noticeable at the spatula end. Since this is relatively thin for some distance, the alloy applied to the outer face composed a relatively larger cross-section than at the pointed end. Even very slight wearing away of the steel left a wear-resisting knife edge which was effective in digging very hard materials, such as marble and concrete, although a slight loss of alloy by chipping resulted. The unmodified steel spatula was badly bruised and roughened by sandstone, concrete and marble. Practically no effective digging was done on the two latter materials by the original steel pick.

It is the conclusion of the writer that the usefulness and effective life of this valuable tool can be materially increased by the application of Haynes Stellite[2] or some similar hard-facing alloy. These improved picks are not on the market. Perhaps it should be noted that the application of this alloy requires the services of a good welding operator. In addition, the alloy is too hard for machining and must be finished by grinding.

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[3] *Oxy-Acetylene Tips*, 6: 58, 1928.

[4] The general idea of the testing machine was described to Mr. J. M. Holeman and Mr. J. B. Weems, Jr., students at Randolph-Macon College. The writer expresses his appreciation of the time and efforts expended by them in designing and constructing it.

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